OPTIMIZATION OF SELECTIVE LASER SINTERING PROCESS PARAMETERS FROM POWDER PROPERTIES: POLYAMIDE 12/CARBON FIBER CASE STUDY

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Abstract

Selective Laser Sintering (SLS) is an additive manufacturing technology that is widely used for rapid prototyping and low-volume production of polymer based parts. The optimization of process parameters represents one of the major drawbacks of this technology since it is largely empirical and based on performing a series of trial-and-error builds. This approach is time consuming, costly and it ignores the properties of starting powder. This presentation provides new results into the prediction of processing conditions starting from the material properties. The model of quasi-isothermal laser sintering and the stable sintering region (SSR) approach has been applied to the powder bed temperature (T_{bed}) and laser exposure parameters respectively. A polyamide 12 powder filled with chopped carbon fibers (PA12/CF) was used to validate these methods. The results show that the sintering window, defined as the temperature range between melting and crystallization, is effective to guide the choice of the powder bed temperature and avoid the distorsion of the sintered parts. The stable sintering region (SSR) defines the processing window between polymer melting and degradation in terms of energy density; it can be conveniently expressed using the Energy to Melt Ratio (EMR) parameter, which puts into relation material properties and process parameters. However, the analysis of mechanical properties, void content and dimensional accuracy of the printed parts reveals that the range of laser energy density values suitable for optimal part properties is significantly smaller than the SSR. Benefits and drawbacks of the SSR approach are therefore highlighted along with suggestions on possible improvements. In fact, enhancing the predictive quality of the process window could help to develop new laser sintering materials, offering potential to save time and material whilst maximizing part properties.

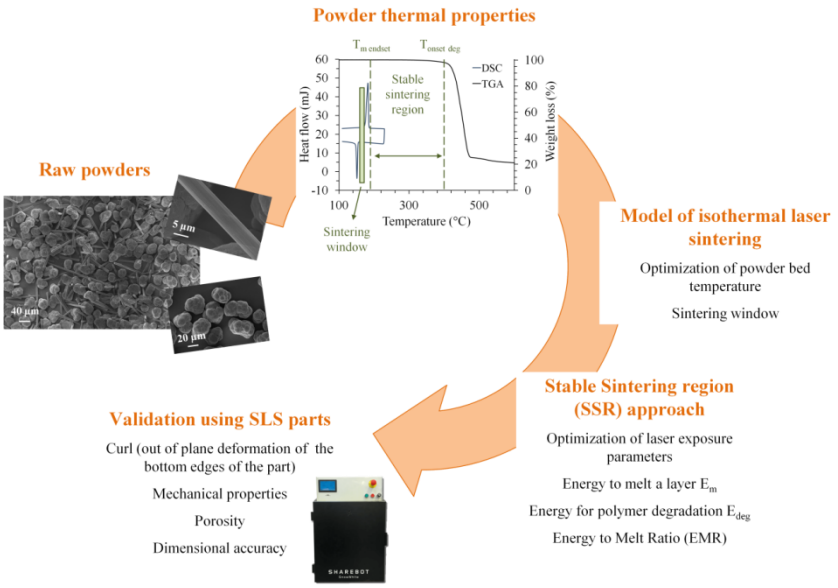

Figure 1 – Process flow adopted in the optimization of process parameters of a polyamide 12 powders filled with short carbon fibers for Selective Laser Sintering: from powder characterization to process window prediction and validation using printed part properties

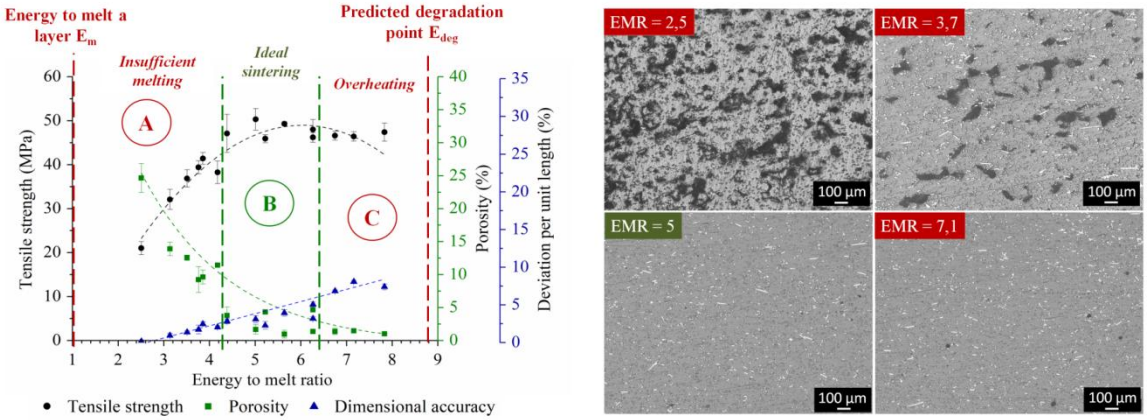

Figure 2 - (left image) Effect of laser energy density on tensile strength, porosity and dimensional accuracy of PA12/CF sintered samples and (right image) optical micrographs of XZ cross sections of PA12/CF parts produced using different laser energy density values